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(54) TELECOMMUNICATIONS NETWORK HAVING SHARED PROTECT CAPACITY ARCHITECTURE

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(56) References cited:
- HIDEO IMANAKA ET AL: "A RECONFIGURATION METHOD FOR FIBER OPTIC SUBSCRIBER LOOPS" ELECTRONICS & COMMUNICATIONS IN JAPAN, PART I - COMMUNICATIONS, vol. 78, no. 6, 1 June 1995, pages 54-66, XP000525935
- HAMAZUMI Y ET AL: "NUMBER OF WAVELENGTHS REQUIRED FOR CONSTRUCTING OPTICAL PATH NETWORK CONSIDERING RESTORATION" ELECTRONICS & COMMUNICATIONS IN JAPAN, PART I - COMMUNICATIONS, vol. 78, no. 7, 1 July 1995, pages 30-41, XP000531470
- SOSNOSKY J ET AL: "SONET RING APPLICATIONS FOR SURVIVABLE FIBER LOOP NETWORKS" IEEE COMMUNICATIONS MAGAZINE, vol. 29, no. 6, 1 June 1991, pages 51-58, XP000235725

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Description

Technical Field

[0001] The invention relates generally to telecommunication networks and, more particularly, to a telecommunications network having a shared protect capacity architecture in which overlapping rings share protect lines.

Background of the Invention

[0002] A telecommunications network, for example, the public switched telephone exchange (PSTN), enables the transfer of voice and data between terminals at geographically separated locations. One such network can be comprised of a series of nodes, each typically located in a city or other high traffic location, coupled together in a closed loop or ring architecture by fiber optic cables. The information travels along the fiber optic cables according to an optical transmission standard commonly known as either synchronous digital hierarchy (SDH) or synchronous optical networks (SONET). Ring architectures have long been preferred for such networks since they provide two separate paths for the flow of information between any two nodes of the ring.

[0003] In a fiber optic network which utilizes a four fiber ring architecture, traffic between adjacent nodes is normally carried on a first optical fiber commonly referred to as a working line. The nodes are also coupled together by a second optical fiber commonly known as a protect line. The diverse protect lines are use to restore the flow of information through the network during a failure or break in the lines which couple adjacent nodes of the network. Specifically, when the lines which couple adjacent nodes break, switching technology within the network nodes will re-route traffic between the nodes along an alternate path using the protect lines to circumvent the cable failure, thereby avoiding network outage.

[0004] Most networks are configured in a multi-ring architecture. In such networks, more than one ring will share a common node. Other multi-ring networks include overlapping ring sections, which result when a pair of rings share two or more adjacent nodes. If information transfers between the rings are possible, for example, at either of the common nodes, the overlapping ring section is said to be interconnected. A conventionally configured overlapping ring section with two rings, which is interconnected at both of the shared nodes, uses two bidirectional working lines and two bidirectional protect lines to couple the nodes. Of these lines, however, one working and one protect are dedicated to each one of the pair of rings. Accordingly, if a break occurs in one of the rings and the network re-routes traffic through the overlapping section thereof, the re-routed traffic will use the protect line dedicated to that ring. Consequently, one protect line in the overlapping ring section is redundant and not used.

[0005] Therefore what is needed is a method and an apparatus to eliminate redundant protect lines in an overlapping or on an inter-connecting route amount rings, thereby achieving tremendous savings in equipment and fiber costs, which does not sacrifice the quality of service or network capacity and survivability.

Summary of the Invention

[0006] According to the invention, there is provided a multi-ring optical communication network with a reduced number of protect lines, the multi-ring optical communication network comprising first and second working rings, said working rings comprising a plurality of working lines and a plurality of unshared nodes, said first and second working rings sharing an overlapping section having first and second shared nodes, a first working line forming part of said first working ring and a second working line forming part of said second working ring, and a plurality of protect lines, each one of the plurality of protect lines connecting one of the plurality of unshared nodes to one other of the plurality of nodes connected by one of the plurality of working lines, wherein said overlapping section further comprises a protect line which is shared by said first working ring and said second working ring.

[0007] The present inventionreduces the cost of constructing a multi-ring optical network having interconnected overlapping ring sections by providing an optically switched path in which the overlapping ring sections share a common protect line. In this manner, costs associated with the construction and maintenance of a second protect line for each overlapping ring section is eliminated. Further, since simultaneous breaks in each of the two rings which share the overlapping ring section is highly unlikely, the cost savings are achieved without a corresponding reduction in the survivability of the network to handle outages. To this end, the optical network is comprised of a plurality of nodes. Working lines connect the nodes to form a pair of rings in which two of the nodes are shared while the remainder are unshared. A shared protect line connects the two shared nodes. Those unshared nodes coupled together by a working line are further coupled by a corresponding protect line.

[0008] In one aspect thereof, the shared node includes first and second Add-Drop Multiplexers, each of which connect the shared node to the working and protect lines which couple the shared node to an unshared node of a respective one of the pair of rings, and an optical cross connect which couples each of the first and second Add-Drop Multiplexers to the shared protect line.

[0009] An advantage of the present invention is that the quantity of equipment and fiber used in the network are reduced, thereby resulting in tremendous cost savings. Furthermore, the network costs are significantly reduced while the improvements achieved by the present

invention work on any network type because the present invention is transparent to the bit or baud rate. Additionally, the present invention works with any type of optical fiber and/or cable and signal formatting.

[0010] The invention also provides a method of reducing protect lines in a multi-ring optical communication network.

Brief Description of the Drawings

[0011] Fig. 1 is a block diagram of a multi-ring optical network having an interconnected overlapping ring section embodying features of the present invention.

[0012] Fig. 2 is an enlarged block diagram of a portion of the optical network of Fig. 1 showing the interconnection between a pair of shared nodes thereof.

[0013] Fig. 3 is a block diagram of a multi-ring optical network having multiple interconnected overlapping ring sections.

Description of a Preferred Embodiment

[0014] Fig. 1 illustrates a multi-ring optical communication network, generally designated 10, having two shared nodes 14 and 20, four unshared nodes designated 12, 16, 18, and 22, working lines 30, protect lines 32, a shared protect line 34, Line Regenerating Equipment (LREs) 24, and optical amplifiers 26, such as Multiwavelength Optical Repeaters (MORs). While, in the disclosed embodiment of the invention, the multi-ring optical communication network 10 is established in accordance with the SONET protocol, it should be clearly understood that the invention is equally suitable for use with other types of optical communication networks. It should be further understood that the disclosure of the multi-ring optical communication network 10 as having two rings which share a single overlapping ring section interconnected at opposite ends thereof by respective ones of two shared nodes and having an equal number of unshared nodes is purely exemplary and that a multi-ring optical communication network 10 constructed in accordance with the teachings of the present invention may be variously configured as to the number of rings, overlapping sections, shared nodes and unshared nodes.

[0015] As an optical signal travels through the multi-ring optical communication network 10, for example, along path 11, losses resulting in reduced signal strength occur. In order to overcome the losses in signal strength, LREs 24 and optical amplifiers 26 are used to regenerate the signal strength as it travels between coupled pairs of the nodes 12, 14, 16, 18, 20 and 22. The distance separating the LREs 24 and the optical amplifiers 26 depends on a number of factors such as the bit rate, fiber type, and the technology used by an owner of the network.

[0016] As previously stated, the multi-ring optical communication network 10 is comprised of a combination of unshared nodes 12, 16, 18 and 22 and shared nodes 14 and 20. The working lines 30 are configured for bi-directional exchanges of optical data between adjacent nodes coupled to opposite ends thereof. Accordingly, the working lines 30 carry all traffic between the nodes coupled thereby. While a single working line 30 typically couples each pair of adjacent nodes, for overlapping ring sections, two working lines 30 couple the adjacent nodes. For example, in the multi-ring optical communication network 10, the shared node 14 is coupled to the shared node 20 by two working lines 30 while the remaining nodes are coupled to the adjacent nodes by a single working line 30. Thus, the unshared node 12 is coupled to the shared node 14 via a single working line 30. In a similar manner, the shared node 14 is coupled to the unshared node 16, the unshared node 16 is coupled to the unshared node 18, the unshared node 18 is coupled to the shared node 20, the shared node 20 is coupled to the unshared node 22, and the unshared node 22 is coupled to the unshared node 12 by a single working line 30. For the overlapping ring section which extends between the shared node 14 and the shared node 20, a first one of the two working lines 30 is part of a ring 11 which couples the nodes 12, 14, 20 and 22 while a second one of the two working lines 30 is part of a ring 13 which couples the nodes 14, 16, 18 and 20.

[0017] In use, the working lines 30 in the multi-ring optical communication network 10 will sometimes fail, for example, when a physical break occurs in the working line 30. In order to prevent disruptions in the flow of traffic, protect lines 32 are used, in conjunction with a shared protect line 34, as a back-up to the working lines 30. Protect lines 32 connect unshared nodes that form the non-overlapping sides of the rings 11 and 13 to the shared nodes 14 and 20. For example, the protect line 32 connects the node 12 to the shared node 14 of the ring 11. In a similar manner, protect lines 32 connect the shared node 14 to the unshared node 16, the unshared node 16 to the unshared node 18, the unshared node 18 to the shared node 20, the shared node 20 to the unshared node 22, and the unshared node 22 to the unshared node 12. Where the ring 11 and the ring 13 overlap, the shared protect line 34 connects the shared node 14 to the shared node 20.

[0018] If a break occurs along a section of the ring, for example, if a break 36 (shown in phantom in Fig. 1) occurs between the unshared node 12 and the unshared node 22 of the ring 11, information can no longer be transferred between the unshared node 12 and the unshared node 22 using the working line 30 for the ring section where the break 36 has occurred. As breaks, such as the break 36, typically sever both the working line 30 and the protect line 32, the protect line 32 connecting the unshared nodes 12 and 22 is similarly unavailable for use. The break 36 is detected by switching circuitry residing within the nodes 12 and 22 located on either side of the break 36 in the ring 11. Upon detection

thereof, a break signal (not shown) is sent to all other nodes that are part of the ring 11. The nodes 12, 14, 20 and 22 will act to re-route all traffic between the unshared nodes 12 and 22 along the protect line 32 coupling the unshared node 12 and the shared node 14, the shared protect line 34 coupling the shared nodes 14 and 20 and the protect line 32 coupling the shared node 20 and the unshared node 22, thereby allowing traffic between unshared nodes 12 and 22 to continue despite the break 36 in the ring section coupling the unshared nodes 12 and 22.

[0019] The aforementioned re-routing is achieved by the components of the switching circuitry which reside at each node 12, 14, 20 and 22. These components switch and restore traffic throughout the ring 11 using the protect lines 32 and the shared protect line 34. Consequently, traffic that would have traveled along the working line 30, between the unshared nodes 12 and 22, travels along the protect lines 32 and the shared protect line 34 of ring 11. Fig. 2 shows, in detail, the switching components which reside at the shared node 14 and the shared node 20. The shared node 14 contains a pair of 4 Fiber Add-Drop Multiplexers (ADMs) 40 and an optical cross connect (OXC) 42. The ADM 40 has four bidirectional ports. In an alternative embodiment the ADM 40 could be configured with eight unidirectional ports. Two opposite ports of the ADM 40 are connected to working lines 30; a third port is connected to the protect line 32 and a fourth port is connected to the OXC 42, as discussed below. The OXC 42 has three ports 50, 52, and 54. Port 54 of the OXC 42 is connected to the shared protect line 34. An internal switch 56 optically connects the port 54 to either the port 50 or the port 52 depending on the location of the break 36 in Fig. 1. The port 50 is connected to one port of the ADM 40 using a connecting path 58, to handle traffic for the ring 13 should a line break occur in the ring 13. Likewise, the port 52 of the OXC 42 is connected to one port of the other ADM 40, located at shared node 14, using a connecting line 59 to handle traffic for the ring 11 should the line break occur in the ring 11. Similarly, the shared node 20 contains a pair of ADMs 60 and a OXC 62. The pair of ADMs 60 each have four bidirectional ports. Two opposite ports are connected to working lines 30; a third port is connected to the protect line 32 and a fourth port to the OXC 62. The OXC 62 has three ports 70, 72, and 74. The port 74 is connected to the shared protect line 34. An internal switch 76 optically connects the port 74 to either the port 70 or the port 72 depending on the location of the break 36 in Fig. 1. The port 70 is connected to one port of the ADM 60 using a connecting path 68, to handle traffic for the ring 13 should a line break occur in the ring 13. Likewise, the port 72 is connected to one port of the other ADM 60 using a connecting path 69, to handle traffic for the ring 11 should a line break occur in the ring 11.

[0020] When the break 36 occurs, the break signal is sent to the ADMs 40 residing on the ring 11, to the OXC 42 and to the OXC 62. The break signal causes the internal switch 56 of the OXC 42 to optically connect the port 52 to the port 54. Similarly, the break signal causes the internal switch 76 of the OXC 46 to optically connect the port 72 to the port 74. Thus, the ADM 40 for the ring 11 located at the shared node 14 is optically connected to the ADM 60 for the ring 11 located at the shared node 20. Hence, an optical path is created between the shared node 14 and the shared node 20 through the shared protect line 34.

[0021] The unshared nodes 12, 16, 18, and 22 operate in the same way as the shared nodes 14 and 20, but without the OXC 42 and 62 because there are no shared protect lines connected to the unshared nodes 12, 16, 18, and 22. Accordingly, the third and the fourth ports of the ADM 40 located at each node are optically coupled to the protect lines 32. For example, node 12 has only one ADM (not shown) connected to a pair of working lines 30 and a pair of protect lines 32 to route traffic along the protect line 32 to the shared node 14. Accordingly, when the break 36 occurs in the ring 11, traffic at the unshared node 12 is re-routed through the protect line 32 that couples the unshared node 12 and the shared node 14, the ADM 40 at the shared node 14, the connecting line 59, the OXC 42, the shared protect line 34, the OXC 62, the connecting line 69, the ADM 40 at the shared node 20 and the protect line 32 that connects the shared node 20 to the unshared node 22. Consequently, a complete path is created using only a single protect line, the shared protect line 34, between the overlapping portion of two different rings.

[0022] Fig. 3 shows another multi-ring optical communication network, generally designated 10', having five shared nodes designated 14', 18', 20', 22', and 14", and four unshared nodes 12', 16', 12" and 16", working lines 30', protect lines 32', shared protect lines 34', ADMs (not shown), OXCs (not shown), LRE 24', and Optical amplifier 26'. The multi-ring optical communication multi-ring optical communication network 10' has four rings designated 11', 13', 11", and 13". Thus, the multi-ring optical communication network 10' is similar to the multi-ring optical communication network 10, of Fig. 1, except there are three more nodes and two more rings in the network 10'. Accordingly, the multi-ring optical communication network 10' handles a break in the working line 30' similar to the multi-ring optical communication network 10, in Fig. 2. The shared node 14' and the shared node 14" function similar to the shared node 14 of the network 10, in Fig. 1. The shared node 20' differs from the shared node 20, in Fig. 2; the shared node 20' has two more ADMs and three more OXCs because the shared node 20' handles the traffic for the rings 11', 13', 11", and 13". Thus, if a break (not shown) occurs between the unshared nodes 12' and 22' of the ring 11', the traffic is re-routed through the protect line 32', located between the unshared node 12' and the shared node 14', and the shared protect paths 34' located between the shared nodes 14', 20' and 22' using the ADMs and OXCs at the shared nodes 14', 20' and 22'.

[0023] By configuring overlapping sections of a multi-ring optical network in this manner, unnecessarily redundant equipment purchases caused by providing a pair of protect lines between each pair of share nodes has been eliminated. Specifically, each protect line connecting the shared nodes includes a number of LREs, Optical amplifiers or other types of optical fiber amplifiers and Wave Division Multiplexers (WDMs). Elimination of one of the two protect lines in the overlapping network ring section would result in tremendous cost savings since about 40% of the cost associated with setting up an optical network is consumed by the LREs. Accordingly, reducing the number of lines between two nodes reduces the number of LREs and optical amplifiers, thereby resulting in dramatic cost savings.

[0024] In another embodiment additional multi-ring optical networks can be established, such as stacked rings. The additional multi-ring optical networks geographically incorporate the same cities or nodes as an existing multi-ring optical network ring, but operate independent of each other. These additional multi-ring optical networks operate in the same manner as the multi-ring optical network 10 of Fig. 1. Thus, utilizing shared protect lines in the additional multi-ring optical networks results in further cost savings.

Claims

1. A multi-ring optical communication network with a reduced number of protect lines, the multi-ring optical communication network comprising first and second working rings (11,13), said working rings (11,13) comprising a plurality of working lines and a plurality of unshared nodes, said first and second working rings (11,13) sharing an overlapping section having first and second shared nodes (14,20), a first working line (30) forming part of said first working ring (11) and a second working line (30) forming part of said second working ring (13), and a plurality of protect lines, each one of the plurality of protect lines connecting one of the plurality of unshared nodes to one other of the plurality of nodes connected by one of the plurality of working lines, **characterised in that** said overlapping section further comprises a protect line (34) which is shared by said first working ring (11) and said second working ring (13).

2. The multi ring optical communication network of claim 1, **characterised in that** said first shared node (14) of said overlapping section of said first and second working rings (11,13) further comprises:

    a first Add-Drop Multiplexer (40) having a first pair of opposite ports optically coupled to a first working line (30) of a non-overlapping section of said first working ring (11) and to said first working line (30) of said overlapping section of said first working ring (11) and one port of a second pair of opposite ports optically coupled to a first protect line (32) of said non-overlapping section of said first working ring (11);
    a second Add-Drop Multiplexer (40) having a first pair of opposite ports optically coupled to a first working line (30) of a non-overlapping section of said second working ring (13) and to said second working line (30) of said overlapping section of said second working ring (13) and one port of a second pair of opposite ports optically coupled to a first protect line (32) of said non-overlapping section of said second working ring (13); and
    a first optical cross connect (42) comprising:

        a first port (52) optically coupled to a second port of said second pair of opposite ports of the first Add-Drop Multiplexer (40) through a first connecting line (59);
        a second port (50) optically coupled to a second port of said second pair of opposite ports of said second Add-Drop Multiplexer (40) through a second connecting line (58);
        a third port (54) optically coupled to said second shared node (20) through said shared protect line (34); and
        an internal switch (56) for selectively coupling one of said first and second ports (52 and 50) of said first optical cross connect (42) to said third port (54) of said first optical cross connect (42).

3. The multi-ring optical communication network of claim 2, **characterized in that** said first and second Add-Drop Multiplexers are 4-Fiber Add-Drop Multiplezers.

4. The multi-ring optical communication network of claim 3, **characterized in that** said second shared node (20) of said overlapping section further comprises:

    a third Add-Drop Multiplexer (60) having a first pair of opposite ports optically coupled to a second working line (30) of said non-overlapping section of said first working ring (11) and to said first working line (30) of said overlapping section of said first working ring (11) and one port of a second pair of opposite ports optically coupled to a second protect line (32) of said non-overlapping section of said first working ring (11);
    a fourth Add-Drop Multiplexer (60) having a first pair of opposite ports optically coupled to a second working line (30) of said non-overlapping

section of said second working ring (13) and to said second working line (30) of said overlapping section of said second working ring (13) and one port of a second pair of opposite ports optically coupled to a second protect line (32) of said non-overlapping section of said second working ring (13); and

a second optical cross connect (62), comprising:

a first port (72) optically coupled to a second port of said second pair of opposite ports of said third Add-Drop Multiplexer (60) through a third connecting line (69);

a second port (70) optically coupled to a second port of said second pair of opposite ports of said fourth Add-Drop Multiplexer (60) through a fourth connecting line (68);

a third port (74) optically coupled to said first shared node (14) through said shared protect line (34); and

an internal switch (76) for selectively coupling one of said first and second ports (72 and 70) of said second optical cross connect (62) to said third port (74) of said second optical cross connect (62).

5. The multi-ring optical communication network of claim 4, **characterized in that** said third and fourth Add-Drop Multiplexers are 4-Fiber Add-Drop Multiplexers.

6. A method of reducing protect lines in a multi-ring optical communication network (10) having first and second working rings (11,13), comprising the steps of providing first and second working rings (11,13) comprising a plurality of working lines and a plurality of unshared nodes, said first and second working rings (11,13) sharing an overlapping section having first and second shared nodes (14,20), a first working line (30) forming part of said first working ring (11) and a second working line (30) forming part of said second working ring (13), and providing a first protect line between said first and second shared nodes (10,14), and a plurality of protect lines, each one of the plurality of protect lines connecting one of the plurality of unshared nodes to one other of the plurality of nodes connected by one of the plurality of working lines, **characterised in that**:

the step of providing a first protect line between said first and second shared nodes (14,20) comprises the step of providing a protect line (34) shared by said first working ring (11) and said second working ring (13), said first working ring (11) using said shared protect line (34) as part of a protect path (32,34) for said first working ring (11) in the event of a break in said first working ring (11) and said second working ring (13) using said shared protect line part of a protect path (32,34) in the event of a break in said second working ring (13).

7. The method of claim 6, **characterized in that**:

the step of providing a protect line (34) shared by said first working ring (11) and said second working ring (13) further comprises the steps of:

optically coupling an input port of a first Add-Drop Multiplexer (40) of said first shared node (14) to a first protect line (30) of said first working ring (11) and coupling an output port of said first Add-Drop Multiplexer (40) of said first shared node (14) to a first port (59) of an optical cross connect (42) of said first shared node (14) using a first connecting line (59);

optically coupling an input port of a second Add-Drop Multiplexer of said first shared node (14) to a first protect line (30) of said second working ring (13) and coupling an output port of said second Add-Drop Multiplexer (40) of said first shared node (14) to a second port (50) of said optical cross connect (42) of said first shared node (14) using a second connecting line (58); and

optically coupling a third port (54) of said optical cross connect of said first shared node (14) to said second shared node (20) through said shared protect line (34).

8. The method of claim 7, **characterized in that**:

the step of providing a protect line (34) shared by said first working ring (11) and said second working ring (13) further comprises the steps of:

optically coupling an input port of a first Add-Drop Multiplexer (60) of said second shared node (20) to a second protect line (30) of said first working ring (11) and coupling an output port of said first Add-Drop Multiplexer (60) of said second shared node (20) to a first port (72) of an optical cross connect (62) of said second shared node (20) using a third connecting line (69);

optically coupling an input port of a second Add-Drop Multiplexer (60) of said second shared node (20) to a second protect line (30) of said second working ring (13) and coupling an output port of said second Add-Drop Multiplexer (40) of said second shared node (20) to a second port (50) of said optical cross connect (62) of said second shared node (20) using a fourth con-

necting line (68); and
optically coupling a third port (74) of said optical cross connect (62) of said second shared node (20) to said first shared node (14) through said shared protect line (34).

Patentansprüche

1. Optisches Mehr-Ring-Kommunikationsnetz mit einer verringerten Anzahl von Schutzleitungen, wobei das optische Mehr-Ring-Kommunikationsnetz erste und zweite Betriebsringe (11, 13), wobei die Betriebsringe (11, 13) eine Mehrzahl von Betriebsleitungen und eine Mehrzahl von nicht gemeinsamen Knoten umfassen, wobei den ersten und zweiten Betriebsringen (11, 13) ein überlappender Abschnitt mit ersten und zweiten gemeinsamen Knoten (14, 20) gemeinsam ist, wobei eine erste Betriebsleitung (30) einen Teil des ersten Betriebsringes (11) bildet und eine zweite Betriebsleitung (30) einen Teil des zweiten Betriebsringes (13) bildet, und eine Mehrzahl von Schutzleitungen umfaßt, wobei jede eine der Mehrzahl von Schutzleitungen einen der Mehrzahl von nicht gemeinsamen Knoten mit einer anderen der Mehrzahl von Knoten verbindet, die durch eine der Mehrzahl von Betriebsleitungen verbunden sind, **dadurch gekennzeichnet, daß** der überlappende Abschnitt weiterhin eine Schutzleitung (34) umfaßt, die dem ersten Betriebsring (11) und dem zweiten Betriebsring (13) gemeinsam ist.

2. Optisches Mehr-Ring-Kommunikationsnetz nach Anspruch 1, **dadurch gekennzeichnet, daß** der erste gemeinsame Knoten (14) des überlappenden Abschnittes der ersten und zweiten Betriebsringe (11, 13) weiterhin folgendes umfaßt:

    einen ersten Hinzufügungs-/Verzweigungs-Multiplexer (40) mit einem ersten Paar von gegenüberliegenden Ports, die optisch mit einer ersten Betriebsleitung (30) eines nicht überlappenden Abschnittes des ersten Betriebsringes (11) und mit der ersten Betriebsleitung (30) des überlappenden Abschnittes des ersten Betriebsringes (11) gekoppelt sind, wobei ein Port eines zweiten Paares von gegenüberliegenden Ports optisch mit einer ersten Schutzleitung (32) des nicht überlappenden Abschnittes des ersten Betriebsringes (11) gekoppelt ist;
    einen zweiten Hinzufügungs-/Verzweigungs-Multiplexer (40) mit einem ersten Paar von gegenüberliegenden Ports, die optisch mit einer ersten Betriebsleitung (30) eines nicht überlappenden Abschnittes des zweiten Betriebsringes (13) und mit der zweiten Betriebsleitung (30) des überlappenden Abschnittes des zweiten Betriebsringes (13) gekoppelt sind, wobei ein Port eines zweiten Paares von gegenüberliegenden Ports optisch mit einer ersten Schutzleitung (32) des nicht überlappenden Abschnittes des zweiten Betriebsringes (13) gekoppelt ist; und
    eine erste optische Kreuzverbindung (42), die folgendes umfaßt:

        einen ersten Port (52), der mit einem zweiten Port des zweiten Paares von gegenüberliegenden Ports des ersten Hinzufügungs-/Verzweigungs-Multiplexers (40) über eine erste Verbindungsleitung (59) gekoppelt ist;
        einen zweiten Port (50), der optisch mit einem zweiten Port des zweiten Paares von gegenüberliegenden Ports des zweiten Hinzufügungs-/Verzweigungs-Multiplexers (40) über eine zweite Verbindungsleitung (58) gekoppelt ist;
        einen dritten Port (54), der optisch mit dem zweiten gemeinsamen Knoten (20) über die gemeinsame Schutzleitung (34) verbunden ist; und
        einen internen Schalter (56) zum selektiven Koppeln eines der ersten und zweiten Ports (52 und 50) der ersten optischen Kreuzverbindung (42) mit dem dritten Port (54) der ersten optischen Kreuzverbindung (42).

3. Optisches Mehr-Ring-Kommunikationsnetz nach Anspruch 2, **dadurch gekennzeichnet, daß** die ersten und zweiten Hinzufügungs-/Verzweigungs-Multiplexer Vier-Faser-Hinzufügungs-/Verzweigungs-Multiplexer sind.

4. Optisches Mehr-Ring-Kommunikationsnetz nach Anspruch 3, **dadurch gekennzeichnet, daß** der zweite gemeinsame Knoten (20) des überlappenden Abschnittes weiterhin folgendes umfaßt:

    einen dritten Hinzufügungs-/Verzweigungs-Multiplexer mit einem ersten Paar von gegenüberliegenden Ports, die optisch mit einer zweiten Betriebsleitung (30) des nicht überlappenden Abschnittes des ersten Betriebsringes (11) und mit der ersten Betriebsleitung (30) des überlappenden Abschnittes des ersten Betriebsringes gekoppelt sind, wobei ein Port eines zweiten Paares von gegenüberliegenden Ports optisch mit einer zweiten Schutzleitung (32) des nicht überlappenden Abschnittes des ersten Betriebsringes gekoppelt ist;
    einen vierten Hinzufügungs-/Verzweigungs-Multiplexer (60) mit einem ersten Paar von gegenüberliegenden Ports die optisch mit einer

zweiten Betriebsleitung (30) des nicht überlappenden Abschnittes des zweiten Betriebsringes (13) und mit der zweiten Betriebsleitung (30) des überlappenden Abschnittes des zweiten Betriebsringes (13) gekoppelt sind, wobei ein Port eines zweiten Paares von gegenüberliegenden Ports optisch mit einer zweiten Schutzleitung (32) des nicht überlappenden Abschnittes des zweiten Betriebsringes (13) gekoppelt ist; und
eine zweite optische Kreuzverbindung (62), die folgendes umfaßt:

einen ersten Port (72), der optisch mit einem zweiten Port des zweiten Paares von gegenüberliegenden Ports des dritten Hinzufügungs-/Verzweigungs-Multiplexer (60) über eine dritte Verbindungsleitung (69) gekoppelt ist;
einen zweiten Port (70), der optisch mit einem zweiten Port des zweiten Paares von gegenüberliegenden Ports des vierten Hinzufügungs-/Verzweigungs-Multiplexer (60) über eine vierte Verbindungsleitung (68) gekoppelt ist,
einen dritten Port (74), der optisch mit dem ersten gemeinsamen Knoten (14) durch die gemeinsame Schutzleitung (34) verbunden ist; und
einen internen Schalter (76) zum selektiven Koppeln eines der ersten und zweiten Ports (72 und 70) der zweiten optischen Kreuzverbindung (62) mit dem dritten Port (74) der zweiten optischen Kreuzverbindung (62).

5. Optisches Mehr-Ring-Kommunikationsnetz nach Anspruch 4, **dadurch gekennzeichnet, daß** die dritten und vierten Hinzufügungs-/Verzweigungs-Multiplexer Vier-Faser-Hinzufügungs-/Verzweigungs-Multiplexer sind.

6. Verfahren zur Verringerung von Schutzleitungen in einem optischen Mehr-Ring-Kommunikationsnetz (10) mit ersten und zweiten Betriebsringen (11, 13), mit den Schritten der Bereitstellung erster und zweiter Betriebsringe (11, 13) die eine Mehrzahl von Betriebsleitungen und eine Mehrzahl von nicht gemeinsamen Knoten umfassen, wobei den ersten und zweiten Betriebsringen (11, 13) ein überlappender Abschnitt gemeinsam ist, der erste und zweite gemeinsame Knoten (14, 20), eine erste Betriebsleitung (30), die einen Teil des ersten Betriebsringes (11) bildet, und eine zweite Betriebsleitung (30), die einen Teil des zweiten Betriebsringes (13) bildet, umfaßt, und Bereitstellung einer ersten Schutzleitung zwischen den ersten und zweiten gemeinsamen Knoten (10, 14) und einer Mehrzahl von Schutzleitungen, wobei jede der Mehrzahl von Schutzleitungen einen der Mehrzahl von nicht gemeinsamen Knoten mit einem anderen der Mehrzahl von Knoten verbindet, die mit einer der Mehrzahl von Betriebsleitungen verbunden sind, **dadurch gekennzeichnet, daß**

der Schritt der Bereitstellung einer ersten Schutzleitung zwischen den ersten und zweiten gemeinsamen Knoten (14, 20) den Schritt der Bereitstellung einer Schutzleitung (34) umfaßt, die dem ersten Betriebring (11) und dem zweiten Betriebsring (13) gemeinsam ist, wobei der erste Betriebring (11) die gemeinsame Schutzleitung (34) als Teil eines Schutzpfades (32, 34) von dem ersten Betriebsring (11) im Fall einer Unterbrechung in dem ersten Betriebsring (11) verwendet, und wobei der zweite Betriebsring (13) den gemeinsamen Schutzleitungsteil eines Schutzpfades (32, 34) im Fall einer Unterbrechung des zweiten Betriebsringes (13) verwendet.

7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, daß**:

der Schritt der Bereitstellung einer Schutzleitung (34), die dem ersten Betriebsring (11) und dem zweiten Betriebsring (13) gemeinsam ist, weiterhin die folgenden Schritte umfaßt:

optisches Koppeln eines Eingangsports eines ersten Hinzufügungs-/Verzweigungs-Multiplexers (40) eines ersten gemeinsamen Knotens (14) mit einer ersten Schutzleitung (30) des ersten Betriebsringes (11) und Koppeln eines Ausgangsports des ersten Hinzufügungs-/Verzweigungs-Multiplexers (40) des ersten gemeinsamen Knotens (14) mit einem ersten Port (59) einer optischen Kreuzverbindung (42) des ersten gemeinsamen Knotens (14) unter Verwendung einer ersten Verbindungsleitung (59);
optisches Koppeln eines Eingangsports eines zweiten Hinzufügungs-/Verzweigungs-Multiplexers des ersten gemeinsamen Knotens (14) mit einer ersten Schutzleitung (30) des zweiten Betriebsringes (13) und Koppeln eines Ausgangsports des zweiten Hinzufügungs-/Verzweigungs-Multiplexers (40) des ersten gemeinsamen Knotens (14) mit einem zweiten Port (50) der optischen Kreuzverbindung (42) des ersten gemeinsamen Knotens (14) unter Verwendung einer zweiten Verbindungsleitung (58); und
optisches Koppeln eines dritten Ports (54) der optischen Kreuzverbindung des ersten gemeinsamen Knotens (14) mit dem zwei-

ten gemeinsamen Knoten (20) über die gemeinsam genutzte Schutzleitung (34).

8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, daß**:

der Schritt der Bereitstellung einer Schutzleitung (34), die dem ersten Betriebsring (11) und dem zweiten Betriebring (13) gemeinsam ist, weiterhin die folgenden Schritte umfaßt:

optisches Koppeln eines Eingangsports eines ersten Hinzufügungs-/Verzweigungs-Multiplexers (60) des zweiten gemeinsamen Knotens (20) mit einer zweiten Schutzleitung (30) des ersten Betriebsringes (11) und Koppeln eines Ausgangsports des ersten Hinzufügungs-/Verzweigungs-Multiplexers (60) des zweiten gemeinsamen Knotens (20) mit einem ersten Port (72) einer optischen Kreuzverbindung (62) des zweiten gemeinsamen Knotens (20) unter Verwendung einer dritten Verbindungsleitung (69);
optisches Koppeln eines Eingangsports eines zweiten Hinzufügungs-/Verzweigungs-Multiplexers (60) des zweiten gemeinsamen Knotens (20) mit einer zweiten Schutzleitung (30) des zweiten Betriebsringes (13) und Koppeln eines Ausgangsports des zweiten Hinzufügungs-/Verzweigungs-Multiplexers (40) des zweiten gemeinsamen Knotens (20) mit einem zweiten Port (50) der optischen Kreuzverbindung (62) des zweiten gemeinsamen Knotens (20) unter Verwendung einer vierten Verbindungsleitung (68); und
optisches Koppeln eines dritten Ports (74) der optischen Kreuzverbindung (62) des zweiten gemeinsamen Knotens (20) mit dem ersten gemeinsamen Knoten (14) über die gemeinsame Schutzleitung (34).

Revendications

1. Réseau optique de télécommunications en anneaux multiples comprenant un nombre réduit de lignes de protection, le réseau optique de télécommunications en anneaux multiples comprenant des premier et deuxième anneaux de travail (11, 13), lesdits anneaux de travail (11, 13) comprenant une pluralité de lignes de travail et une pluralité de noeuds non partagés, lesdits premier et deuxième anneaux de travail (11, 13) partageant une section chevauchante comportant des premier et deuxième noeuds partagés (14, 20), une première ligne de travail (30) faisant partie du premier anneau de travail (11) et une deuxième ligne de travail (30) faisant partie du deuxième anneau de travail (13), et une pluralité de lignes de protection, chaque ligne de la pluralité de lignes de protection reliant un noeud de la pluralité de noeuds non partagés à un autre noeud de la pluralité de noeuds connecté par une ligne de la pluralité de lignes de travail, **caractérisé en ce que** la section chevauchante comprend, en outre, une ligne de protection (34) qui est partagée par ledit premier anneau de travail (11) et ledit deuxième anneau de travail (13).

2. Réseau optique de télécommunications en anneaux multiples selon la revendication 1, **caractérisé en ce que** ledit premier noeud partagé (14) de ladite section chevauchante desdits premier et deuxième anneaux de travail (11, 13) comprend en outre :

un premier multiplexeur d'insertion-extraction (40) comportant une première paire de ports opposés couplés optiquement à une première ligne de travail (30) d'une section non chevauchante dudit premier anneau de travail (11) et à ladite première ligne de travail (30) de ladite section chevauchante dudit premier anneau de travail (11) et un port d'une deuxième paire de ports opposés couplé optiquement à une première ligne de protection (32) de ladite section non chevauchante dudit premier anneau de travail (11) ;
un deuxième multiplexeur d'insertion-extraction (40) comportant une première paire de ports opposés couplés optiquement à une première ligne de travail (30) d'une section non chevauchante dudit deuxième anneau de travail (13) et à ladite deuxième ligne de travail (30) de ladite section chevauchante dudit deuxième anneau de travail (13) et un port d'une deuxième paire de ports opposés couplé optiquement à une première ligne de protection (32) de ladite section non chevauchante dudit deuxième anneau de travail (13) : et
un premier brasseur optique (42) comprenant :

un premier port (52) couplé optiquement à un deuxième port de ladite deuxième paire de ports opposés du premier multiplexeur d'insertion-extraction (40) par l'intermédiaire d'une première ligne de connexion (59) ;
un deuxième port (50) couplé optiquement à un deuxième port de ladite deuxième paire de ports opposés dudit deuxième multiplexeur d'insertion-extraction (40) par l'intermédiaire d'une deuxième ligne de connexion (58) ;
un troisième port (54) couplé optiquement

audit deuxième noeud partagé (20) par l'intermédiaire de ladite ligne de protection partagée (34) ; et
un commutateur interne (56) destiné à coupler de manière sélective l'un desdits premier et deuxième ports (52 et 50) dudit premier brasseur optique (42) audit troisième port (54) dudit premier brasseur optique (42).

3. Réseau optique de télécommunications en anneaux multiples selon la revendication 2, **caractérisé en ce que** lesdits premier et deuxième multiplexeurs d'insertion-extraction sont des multiplexeurs d'insertion-extraction à quatre fibres.

4. Réseau optique de télécommunications en anneaux multiples selon la revendication 3, **caractérisé en ce que** ledit deuxième noeud partagé (20) de ladite section chevauchante comprend en outre :

un troisième multiplexeur d'insertion-extraction (60) comportant une première paire de ports opposés couplés optiquement à une deuxième ligne de travail (30) de ladite section non chevauchante dudit premier anneau de travail (11) et à ladite première ligne de travail (30) de ladite section chevauchante dudit premier anneau de travail (11) et un port d'une deuxième paire de ports opposés couplé optiquement à une deuxième ligne de protection (32) de ladite section non chevauchante dudit premier anneau de travail (11) ;
un quatrième multiplexeur d'insertion-extraction (60) comportant une première paire de ports opposés couplés optiquement à une deuxième ligne de travail (30) de ladite section non chevauchante dudit deuxième anneau de travail (13) et à ladite deuxième ligne de travail (30) de ladite section chevauchante dudit deuxième anneau de travail (13) et un port d'une deuxième paire de ports opposés couplé optiquement à une deuxième ligne de protection (32) de ladite section non chevauchante dudit deuxième anneau de travail (13) : et
un deuxième brasseur optique (62) comprenant :

un premier port (72) couplé optiquement à un deuxième port de ladite deuxième paire de ports opposés dudit troisième multiplexeur d'insertion-extraction (60) par l'intermédiaire d'une troisième ligne de connexion (69) ;
un deuxième port (70) couplé optiquement à un deuxième port de ladite deuxième paire de ports opposés dudit quatrième multiplexeur d'insertion-extraction (60) par l'intermédiaire d'une quatrième ligne de connexion (68) ;
un troisième port (74) couplé optiquement audit premier noeud partagé (14) par l'intermédiaire de ladite ligne de protection partagée (34) ; et
un commutateur interne (76) destiné à coupler de manière sélective l'un desdits premier et deuxième ports (72 et 70) dudit deuxième brasseur optique (62) audit troisième port (74) dudit deuxième brasseur optique (62).

5. Réseau optique de télécommunications en anneaux multiples selon la revendication 4, **caractérisé en ce que** lesdits troisième et quatrième multiplexeurs d'insertion-extraction sont des multiplexeurs d'insertion-extraction à quatre fibres.

6. Procédé pour réduire le nombre de lignes de protection dans un réseau optique de télécommunications en anneaux multiples (10) comportant des premier et deuxième anneaux de travail (11, 13), comprenant les étapes consistant à fournir des premier et deuxième anneaux de travail (11, 13) comprenant une pluralité de lignes de travail et une pluralité de noeuds non partagés, lesdits premier et deuxième anneaux de travail (11, 13) partageant une section chevauchante comportant des premier et deuxième noeuds partagés (14, 20), une première ligne de travail (30) faisant partie dudit premier anneau de travail (11) et une deuxième ligne de travail (30) faisant partie dudit deuxième anneau de travail (13), et à fournir une première ligne de protection entre lesdits premier et deuxième noeuds partagés (14, 20) et une pluralité de lignes de protection, chaque ligne de la pluralité de lignes de protection reliant un noeud de la pluralité de noeuds non partagés à un autre noeud de la pluralité de noeuds connecté par une ligne de la pluralité de lignes de travail, **caractérisé en ce que** :

l'étape consistant à fournir une première ligne de protection entre lesdits premier et deuxième noeuds partagés (14, 20) comprend l'étape consistant à fournir une ligne de protection (34) partagée par ledit premier anneau de travail (11) et ledit deuxième anneau de travail (13), ledit premier anneau de travail (11) utilisant ladite ligne de protection partagée (34) comme partie de son chemin de protection (32, 34) en cas de rupture dans ledit premier anneau de travail (11) et ledit deuxième anneau de travail (13) utilisant ladite ligne de protection partagée comme partie de son chemin de protection (32, 34) en cas de rupture dans ledit deuxième anneau de travail (13).

7. Procédé selon la revendication 6, **caractérisé en ce que** :

l'étape consistant à fournir une ligne de protection (34) partagée par ledit premier anneau de travail (11) et ledit deuxième anneau de travail (13) comprend en outre les étapes consistant à :

coupler optiquement un port d'entrée d'un premier multiplexeur d'insertion-extraction (40) dudit premier noeud partagé (14) à une première ligne de protection (30) dudit premier anneau de travail (11) et à coupler un port de sortie dudit premier multiplexeur d'insertion-extraction (40) dudit premier noeud partagé (14) à un premier port (59) d'un brasseur optique (42) dudit premier noeud partagé (14) en utilisant une première ligne de connexion (59) ;
coupler optiquement un port d'entrée d'un deuxième multiplexeur d'insertion-extraction dudit premier noeud partagé (14) à une première ligne de protection (30) dudit deuxième anneau de travail (13) et à coupler un port de sortie dudit deuxième multiplexeur d'insertion-extraction (40) dudit premier noeud partagé (14) à un deuxième port (50) dudit brasseur optique (42) dudit premier noeud partagé (14) en utilisant une deuxième ligne de connexion (58) ; et
coupler optiquement un troisième port (54) dudit brasseur optique dudit premier noeud partagé (14) audit deuxième noeud partagé (20) par l'intermédiaire de ladite ligne de protection partagée (34).

8. Procédé selon la revendication 7, **caractérisé en ce que** :

l'étape consistant à fournir une ligne de protection (34) partagée par ledit premier anneau de travail (11) et ledit deuxième anneau de travail (13) comprend en outre les étapes consistant à :

coupler optiquement un port d'entrée d'un premier multiplexeur d'insertion-extraction (60) dudit deuxième noeud partagé (20) à une deuxième ligne de protection (30) dudit premier anneau de travail (11) et à coupler un port de sortie dudit premier multiplexeur d'insertion-extraction (60) dudit deuxième noeud partagé (20) à un premier port (72) d'un brasseur optique (62) dudit deuxième noeud partagé (20) en utilisant une troisième ligne de connexion (69) ;
coupler optiquement un port d'entrée d'un deuxième multiplexeur d'insertion-extraction dudit deuxième noeud partagé (20) à une deuxième ligne de protection (30) dudit deuxième anneau de travail (13) et à coupler un port de sortie dudit deuxième multiplexeur d'insertion-extraction (40) dudit deuxième noeud partagé (20) à un deuxième port (50) dudit brasseur optique (62) dudit deuxième noeud partagé (20) en utilisant une quatrième ligne de connexion (68) ; et
coupler optiquement un troisième port (74) dudit brasseur optique (62) dudit deuxième noeud partagé (20) audit premier noeud partagé (14) par l'intermédiaire de ladite ligne de protection partagée (34).

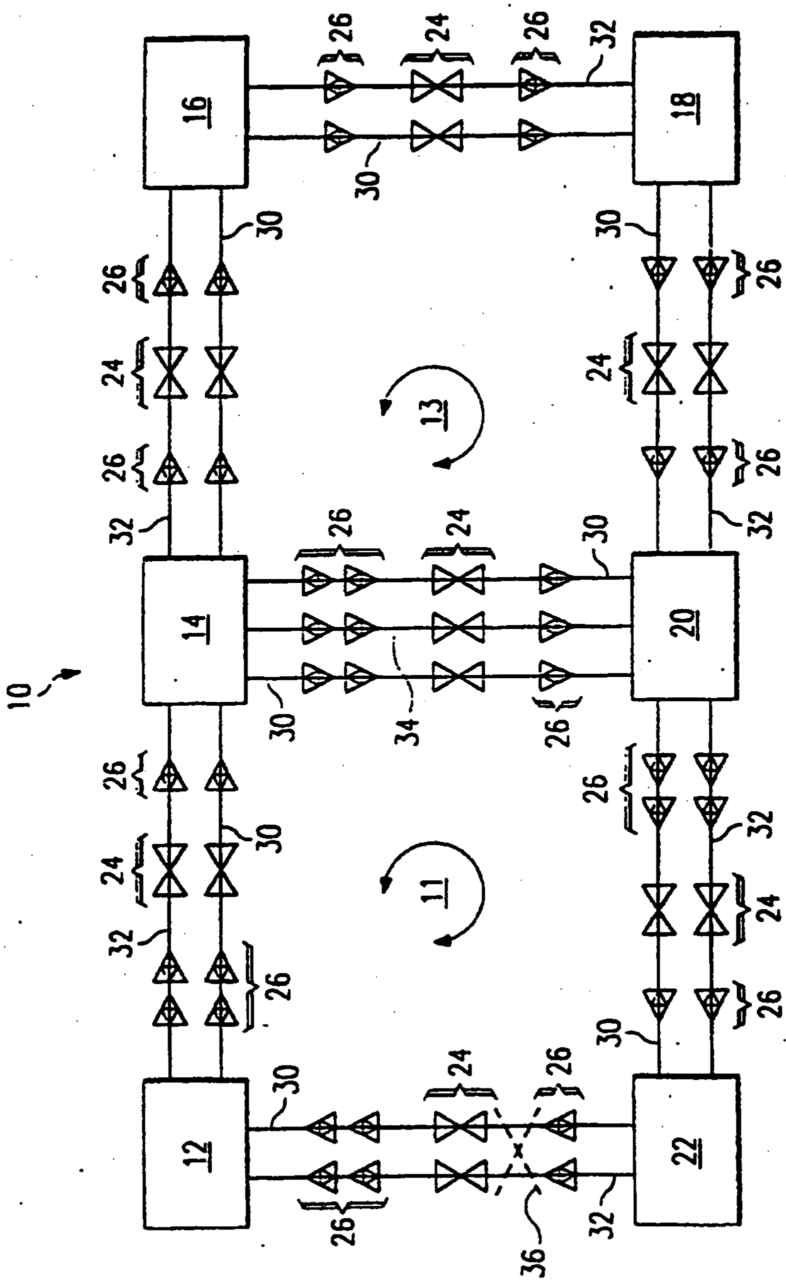

Fig. 1

Fig. 2

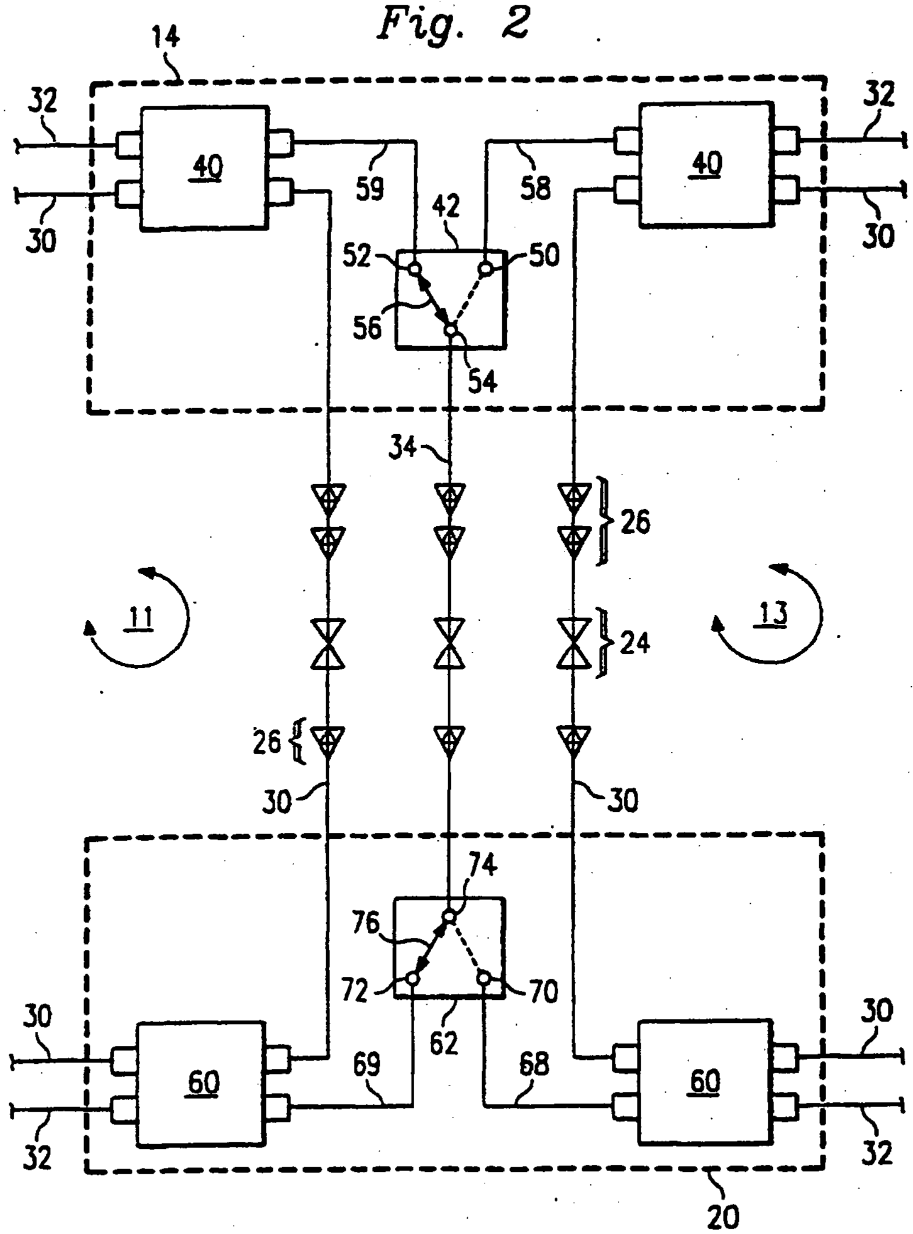
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Fig. 3